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The effect of delivery type (vaginal delivery versus cesarean section) on intraocular pressure and retinal nerve fiber layer thickness in healthy women

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Abstract

Introduction: Pregnancy imposes physiological stress and significantly changes human body. This change may have potential effects on visual system. Little is known about pregnancy effects on intraocular pressure (IOP) and glaucoma.
Objectives: The present study tended to evaluate and compare the effect of normal vaginal delivery (NVD) versus cesarean section (CS) on IOP and retinal nerve fiber layer thickness (RNFLT) in healthy women.
Patients and Methods: Sixty pregnant women participated in this prospective cross-sectional study. The participants were assigned to two groups; the first group consisted of 30 candidates for NVD and the second group of 30 candidates for CS. Then, IOP in three states before delivery, during delivery, and six weeks after delivery then RNFLT were measured and compared by optical coherence tomography (OCT) in two states before delivery and six weeks after delivery.
Results: Based on the results, there was no significant difference in the RNFLT in left and right eyes, before and after delivery in the NVD and CS groups ($P=0.081$ and $P=0.090$, respectively). Additionally, following the comparison of NVD and SC groups, no significant difference in the RNFLT between two groups was detected ($P>0.05$). According to IOP measurements in both eyes, IOP during delivery was significantly higher than before and after delivery in NVD group ($P=0.05$ and $P=0.048$, respectively) and CS group ($P=0.028$ and $P=0.035$, respectively). In addition, IOP in NVD group was higher than CS group in all states, but no statistically significant difference was seen among them ($P>0.05$).
Conclusion: In general, the results showed that delivery type does not significantly affect RNFLT and IOP. It is also possible that an increase in IOP will lead to different results in women with pre-existing glaucoma or risk factors for it. Therefore, in cases with a positive background of glaucoma, specialized examinations and delivery under the supervision of a specialist are recommended.

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Introduction

Pregnancy, as a physiological condition, causes many effects on various organs of the body through hormonal changes (1,2). The eye is one of the organs that is affected by these conditions (2,3). Various changes in the visual system during pregnancy can indicate systemic abnormalities (1,4). Pregnancy can lead to physiological effects on refractive position, changes in the visual field, increased corneal sensitivity, changes in intraocular pressure (IOP) and dry eyes. Similarly, it can cause pathological changes such as retinopathy in the eye (5).

Glaucoma, the most common cause of optic neuropathy in adulthood, leads to the irreversible destruction of ganglion cell axons at the retinal nerve fiber layer thickness (RNFLT) site. In the anatomical structure of the eye, RNFLT is located at the retinal surface and contains axons. Which originate from retinal ganglion cells in the optic nerve pathway. In several conditions, it is clinically important to evaluate the status of RNFLT

Key point

To comparison of the effect of delivery type on intraocular pressure and RNFLT on two groups of NVD and CS, the results showed that despite the increase of IOP during delivery in both groups, there were no significant changes in RNFL thickness after delivery in healthy women, but there is a need for further study on women with a positive background of glaucoma.

(1,5). Therefore, changes in RNFLT are an important biomarker for the detection of axonal lesions (6-9). As a risk factor for glaucoma, increased IOP is influenced by various factors, including genetics, age, race, systemic blood pressure, heart rate and episcleral vein pressure (8-10). The evidence relates IOP to the endocrine system (11).

Numerous hormones affect IOP, the most important of which are female sex hormones (8,9,12). Since these hormones are steroids and affect the balance of salt and water and lead to water retention in the body (8). Little is known about pregnancy's effects on IOP and glaucoma (9). Glaucoma is more common in people over 40 years of age; however, it is also observed in women of the reproductive period (8). Various studies have shown a significant decrease in IOP during pregnancy, particularly in the third trimester (8,13,14), which often returns to normal after delivery. Most physiological changes of pregnancy usually occur in the third trimester, according to the rate of hormonal changes peaks at this time. In the third trimester, pregnant women have higher estrogen levels than non-pregnant women. However, hormonal activity returns to its original state within a few weeks after delivery (8).

Possible mechanisms of physiological decrease in IOP include facilitated exit of aqueous due to hormonal changes (increased progesterone and β-subunit of chorionic gonadotropins), decreased episcleral vein pressure following decreased venous pressure in the upper extremities and metabolic acidosis due to pregnancy (2,14).

The effects of childbirth on vision are unknown. Many ophthalmologists and obstetricians recommend cesarean section (CS) in people with eye disease, assuming that IOP increases during normal delivery (15). In a normal delivery, the mother facilitates delivery through the birth canal by the Valsalva maneuver (16). It has been observed that, this maneuver can increase IOP by the mechanism of increasing intrathoracic pressure followed by the jugular and orbital vein congestion (17). In addition, in some patients, holding their breath affects the IOP by increasing intrathecal pressure. This condition causes a temporary increase in IOP (18,19).

In a study on CS indicators in 4895 women, Socha et al, found that 2.04% of cases were CSs due to eye diseases (20). Some obstacles to vaginal delivery may include myopia, retinal detachment, diabetic retinopathy and glaucoma (15). However, according to previous studies, there is no definite indication in the field of ophthalmology to determine the type of delivery (17), which concerns obstetricians treating women with eye diseases (10).

The greatest concern about the increase in IOP is due to the Valsalva maneuver during labor (17). Studies have shown that changes in IOP during normal delivery are not significant and occur within the normal range of circadian IOP changes (10). Additionally, it has been observed that during cesarean delivery, maneuvers performed to facilitate the exit of the infant and the subsequent hemodynamic changes cause a significant increase in IOP during labor (17). Physicians apply fundal pressure on the abdomen during cesarean delivery (C-section) to facilitate fetus movement through the hysterectomy site, as a result of which, inferior vena cava may compress and venous return may be prevented. Then, intracranial pressure may temporarily increase, which leads to IOP (13,21).

Since, gynecologists usually recommend a CS for women with eye diseases, the effect of fundal pressure and anesthesia is not evident on IOP (13). Moreover, there is little data on the effect of delivery type on IOP changes during labor. There are several stages during childbirth in which numerous physiological changes and drug interventions occur. These conditions may affect IOP, including the position of delivery (lying down, sitting, or kneeling), vascular changes and pharmacological effects (anesthesia factors, oxytocin and other drugs). Therefore, this study tends to evaluate the effect of natural delivery versus C-section on IOP and RNFLT in healthy pregnant women.

Objectives

- Investigating the possible effect of delivery type on RNFLT in healthy women.
- Determining the appropriate type of delivery in women with glaucoma or its risk factors.
- Prevention of possible glaucomatous RNFL damage related to delivery type, in pregnant women.

Patients and Methods

Study design

This prospective cross-sectional study was conducted on full-term pregnant women hospitalized in the Imam Khomeini hospital of Ahvaz during 2019-2020.

Objectives and procedures, as well as benefits and outcomes of the study, were explained to the willing participants. Finally, eligible individuals entered the study if they wished, after obtaining written consent. This study was conducted in the ophthalmology clinic, delivery room and general operating room of this hospital.

Patient evaluation

First, the basic characteristics of the subjects including demographic information (age, gestational age, BMI [body mass index]), medical history and pregnancy history of women were and recorded. The subjects were studied based on the type of delivery in two groups; the first group included full-term pregnant candidates of natural delivery. The second group included full-term pregnant candidates for elective CS with obstetric indications.

Prepartum, intrapartum and postpartum IOP, heart rate and systolic and diastolic blood pressure were measured accordingly. The duration of the operation and the medications used during the delivery (anesthesia, oxytocin) were recorded too. Individuals in both groups

were referred to the eye clinic after the last prenatal visit to measure IOP (Tono-Pen AVIA; Reichert Inc., Depew, New York, USA) and optical coherence tomography (OCT), RNFLT (SPECTRALIS HRA + OCT; Heidelberg Engineering, Heidelberg, Germany).

Intraocular pressure was measured during normal delivery, in the first group at the stage of withdrawal of the baby from the birth canal during uterine contractions and in the second group at the stage of pressure on the uterine fundus. To measure IOP and RNFLT, a tonometer and OCT (SPECTRALIS HRA + OCT; Heidelberg Engineering, Heidelberg, Germany) were used, respectively.

Both groups were asked to return to the ophthalmology clinic six weeks after delivery for re-measurement of IOP and OCT RNFLT. Finally, the difference between IOP before and after delivery and the difference in RNFLT were evaluated. The presence of RNFLT changes greater than 5 microns was considered significant (24).

Inclusion criteria

Age 18 to 45 years, full term pregnant women, single pregnancies, healthy women (no history of systemic and ocular diseases) and signing the written consent form.

Exclusion criteria

Patients undergoing CS as an emergency, IOP >21 mm Hg before delivery, history of glaucoma in first-degree relatives, receiving any systemic medication and no referral for follow-up

Statistical analysis

Statistical analysis was conducted by SPSS software, version 22. Descriptive statistics (mean, standard deviation, frequency and percentage) were carried out for data analysis. Normal data distribution (IOP and RNFLT) was checked by Kolmogorov-Smirnov test. Moreover paired independent *t* test, repeated measures test and chi-square test (or Fisher's exact test) were conducted for data analysis ($P<0.05$).

Results

In total, 60 pregnant women (120 right and left eyes) in the age range of 16 to 39 years (28.2 ± 5.7 years old) were assigned to two groups of 30 (group one; 27.95 ± 5.1 old; group two; 28.44 ± 6.3 old). The first group included 30 women with NVD and the second group included 30 candidates for CS. There was no significant difference between the two groups in terms of age ($P = 0.125$). The demographic variables of the participants are listed in Table 1, which shows no difference between the groups. Furthermore, none of the patients had an underlying eye disease.

In the NVD group, the mean gestational age was 40.5 ± 1.4 weeks (range 38-42 weeks); in the CS group, the mean gestational age was 39.4 ± 1.5 weeks, (range 32-38 weeks) and the difference was not statistically significant ($P>0.05$).

In the NVD group, before delivery as baseline RNFLT in the right and left eyes was 103 ± 4.5 µm and 102 ± 4.1 µm, respectively (range 77-125 µm) and after delivery RNFLT was 101 ± 4.5 µm and 100 ± 4 µm, respectively (range 78-121 µm). Besides, the mean thickness of RNFLT in the CS group before and after delivery in the right and left eyes were 102 ± 4.2 µm and 101 ± 4.5 µm (range 76-125 µm) and 100 ± 3.7 µm and 101 ± 4.1 µm, respectively (range 77-122 µm). Before and after delivery RNFLT of NVD group as well as RNFLT of CS group were compared by paired *t* test (pairwise comparison). In this regard, the results of the study were not significant on a statistical basis between groups (NVD and CS: $P = 0.081$ and $P = 0.090$, respectively), as shown in Table 2.

However, an independent *t* test was conducted to evaluate the difference in before and after delivery RNFLT between the two groups. The results showed that the mean RNFLT in NVD and CS were not significantly different in any of the stages before and after delivery ($P = 0.240$ and $P = 0.495$ respectively), which indicates that the type of delivery does not affect the thickness of RNFLT (Table 3).

The mean IOP in women in the NVD group before delivery in the right and left eyes was 15.05 and 15.21 mm Hg, respectively. During delivery, it was 21.90 and 22.10 mm Hg, respectively. Six weeks after delivery were 14.60 and 14.80 mm Hg. The analysis showed a statistically significant difference between before delivery and during delivery IOP, as well as during delivery and after delivery IOP in the NVD group ($P = 0.05$ and $P = 0.048$,

Table 1. Comparison of basic characteristics in the studied groups

Variables	Level	Study groups		*P* value
		CS	NVD	
Age (y)	Mean ± SD	28.44 ± 6.3	27.95± 5.1	0.105
BMI (kg/m²)	Mean ± SD	26.85 ± 2.58	26. 12 ± 2.05	0.195
Parity	Mean (Median)	2.2 (2)	2.6 (3)	0.428
Gestational Age (wk)	Mean ± SD	39.4± 1.5	40.5± 21.4	0.650
Systolic blood pressure (mm Hg)	Mean ± SD	134.71 (25.31)	130.5 (22.17)	0.244
Diastolic blood pressure (mm Hg)	Mean ± SD	87.30 (17.02)	85.2 (16.12)	0.305

BMI, Body mass index; CS, Cesarean section; NVD, Normal vaginal delivery.

Table 2. Comparison of RNFLT of each group before and after childbirth

Variable	Study groups	Six weeks after delivery		Before delivery		*P* value
		OD	OS	OD	OS	
RNFLT (μm)	NVD	101±4.5	100±4	103±4.5	102±4.1	0.081
	CS	100±3.7	101±4.1	102±4.2	101±4.5	0.090

RNFLT, retinal nerve fiber layer thickness; CS, Cesarean section; NVD, Normal vaginal delivery; OD, right eye; OS, left eye.

Table 3. Comparison of RNFLT of the studied groups in each stage

Variable	Six weeks after delivery				Before delivery			
	CS		NVD		CS		NVD	
	OD	OS	OD	OS	OD	OS	OD	OS
RNFLT (μm)	100	101	101	100	102	101	103	102
P value	0.495				0.240			

RNFLT, retinal nerve fiber layer thickness; CS, Cesarean section; VD, Normal vaginal delivery; OD, right eye; OS, left eye.

respectively). However, the results similarly did not reveal a statistically significant difference between before and after delivery IOP ($P>0.05$), as shown in Table 4.

Another thing to consider was that the mean IOP in CS group women before delivery in the right and left eyes was 15.25 and 15.41 mm Hg, respectively. During delivery were 20.60 and 20.15 mm Hg, respectively. The six weeks after delivery were 14.80 and 15 mm Hg, which according to the results of statistical analysis, the difference in IOP in women candidates for CS, before delivery and during delivery, as well as during delivery and after delivery was statistically significant ($P=0.028$ and $P=0.035$, respectively). IOP before and after delivery did not differ statistically significantly between the subjects ($P>0.05$). Although IOP was slightly higher in the VD group, this difference was not significant at any time (All, $P>0.05$; Table 5).

Discussion

Pregnancy involves extensive changes in the condition of all organs of the body, of which progressive edema is the specific and main cause of this physiological condition. These physiological changes affect cardiovascular, renal, pulmonary, immunological and visual systems (2,22). Literature reports the major effects of pregnancy on visual system. The pregnancy-caused ocular changes may include increased conjunctival discoloration, melasma/chloasma, dry eye syndrome, decreased corneal sensitivity and increased corneal thickness due to edema (22). Therefore, pregnancy causes physiological changes, particularly in the visual system. In general, little is known about pregnancy's effects on vision. Therefore, this study tended to evaluate the effect of NVD versus CS on IOP and RNFLT in healthy pregnant women.

According to the results, before and after delivery

Table 4. Pair comparisons of IOP in each studied group based on stages

Variable	Studied groups	Six weeks after delivery (3)		During delivery (2)		Before delivery (1)		*P* value	
		Right	Left	Right	Left	Right	Left		
IOP	NVD	14.60	14.80	22.90	22.10	15.05	15.21	1&2	0.05*
								1&3	0.320
								2&3	0.048*
	CS	14.80	15	20.60	20.15	15.25	15.41	1&2	0.028*
								1&3	0.128
								2&3	0.035*

IOP, intraocular pressure; CS, Cesarean section; NVD, Normal vaginal delivery.

Table 5. Comparison of IOP in the studied groups in each stage

Variable	Six weeks after delivery				During delivery				Before delivery			
	CS		NVD		CS		NVD		CS		NVD	
	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
IOP	14.80	15	14.60	14.80	16.60	16.20	16.50	16.35	15.25	15.41	15.05	15.21
P value	0.180				0.536				0.221			

IOP, intraocular pressure; CS, Cesarean section; NVD, Normal vaginal delivery.

RNFLT was not statistically significant in the two groups ($P=0.081$ and $P=0.090$, respectively). Correspondingly, independent t test showed that before and after delivery RNFLT was not significantly different in NVD and CS groups ($P=0.240$ and $P=0.495$), which indicates that the type of delivery does not affect the thickness of RNFL. This finding consistent with the literature implies that pregnancy and particularly the delivery method, does not significantly affect RNFLT (13,17). On the contrary, some studies reported significant differences between before and after delivery RNFLT. For example, Tok et al conducted a study to compare the RNFLT during pregnancy and the postpartum period. The results showed that antepartum RNFLT thickness was significantly higher than postpartum (107 ± 9 versus 102 ± 9 microns) (1). Possible reasons for these results may be due to the type of sample in the study. In this study, the average gestational age was 29 weeks, while the average gestational age was about 40 weeks in the our study. Furthermore, in their study, the results were not compared in terms of the type of delivery, while in our study; patients in the two groups of NVD and CS were evaluated and compared.

In general, the increased RNFLT in common antepartum diseases (including diabetes and chronic hypertension or other chronic diseases) may be misdiagnosed because of an increased antepartum thickness (8). Therefore, in these cases, it is better to carry out the delivery under the supervision of a specialist.

Demir et al compared 40 healthy pregnant women and 37 non-pregnant women as control (7). Retinal nerve fiber layer thickness was reported similar in the two groups. Meanwhile, IOP was higher in the control group, which probably affected the RNFLT. In designing this study, reassessing the same population without differences in IOP showed greater RNFLT during pregnancy and after delivery regression. The results of this study were consistent with our study; since, in our study no difference between RNFLT before and after delivery was detected. Nonetheless the mean decreased somewhat after delivery, which was not statistically significant.

Clinically, increased RNFLT in pregnancy may help diagnose retinopathy in some chronic conditions, such as diabetes and hypertension. Decreased RNFLT in these chronic diseases may not be diagnosed correctly in pregnancy, because thickness increases during pregnancy (8). As the most common disease, pregnancy is associated with diabetes which has significantly increased in recent years. For example, diabetes is diagnosed in 4.2% of American pregnant women (15). The underlying diabetic retinopathy may develop during pregnancy because of the restrict control recommended during pregnancy.

In the present study, statistical analysis showed a statistically significant difference between before delivery and during delivery IOP as well as during delivery and after delivery IOP ($P=0.048$ and $P=0.050$, respectively), while no significant difference was observed between before and after delivery IOP in NVD group ($P>0.05$). In the CS group, a significant difference between before delivery and during delivery IOP was seen. Likewise, the same difference during delivery and after delivery IOP was existed ($P=0.035$ and $P=0.028$, respectively); however, this rate before and after pregnancy was not significant in this group. No significant difference was noted between IOP of the two groups in three states ($P>0.05$). This indicates that delivery type did not significantly affect IOP, although its amount was somewhat higher in the NVD group.

The effect of pregnancy on IOP is not exactly known, but various studies have shown a reduction of about 10% in this pressure. In one study, the reduction in IOP in pregnant women with previous higher IOP was greater than the reduction in healthy pregnant women. The most reduction in ocular pressure in healthy individuals was in the 12th and 18th weeks of pregnancy and cases of ocular hypertension in the 24th and 30th weeks of pregnancy; this effect was not related to systemic hypertension (23). In a previous study, Kurtay et al (17) showed that the rate of reduction in IOP in women with a history of multiple pregnancies was higher than in women with first pregnancies, which was attributed to more stress and higher epinephrine levels in early pregnancies. This finding was not consistent with the present study, because no significant relationship was observed between IOP and parity.

Several processes have been proposed to justify lowering eye pressure during pregnancy, for example increasing aqueous humor outflow through the uveoscleral pathway, possibly due to high levels of estrogen, relaxin, progesterone, and human chorionic gonadotropin β (HCGβ). However, this has not yet been proven. Pregnancy-induce acidosis is effective in producing aqueous humor, reducing episcleral pressure, and increasing the output of aqueous humor (8,14). On the other hand, the error of measuring eye pressure or softening of ligaments in the last trimester with radar may reduce eye pressure and soften the cornea and sclera (5). The amount of IOP reduction varies in different articles, in fifteen study analysis IOP dropped 2.9 mm Hg in third trimester, which can be considered as an effective factor in preventing the progression of glaucoma in pregnancy (24), while expected pre-existing glaucoma improves during pregnancy (25), in a retrospective study by Brauner et al (26) on 28 eyes of 15 glaucoma patients, 35% of cases developed glaucoma during pregnancy. Therefore, these patients should be examined regularly. Around 87% of these patients needed to use anti-glaucoma drops to maintain IOP and the effect of reducing IOP by pregnancy alone was not sufficient. Meshi et al (10) investigated the effect of vaginal delivery under epidural anesthesia on IOP and mean ocular perfusion pressure (MOPP) of healthy women; they found a significant difference in IOP and MOPP at different stages of virtual delivery. They finally concluded that vaginal delivery under epidural anesthesia could not significantly damage optic nerve of healthy women; thus, these findings are consistent with

the present study.

Likewise, in a study aimed at investigating the effect of uterine fundus massage on IOP, mothers of candidates for elective CS without a history of eye problems showed that uterine fundus massage during CS significantly increases IOP but anesthesia has no effect on it (17). These findings are consistent with our study.

Chronic hypertension is one of the most common diseases during pregnancy. Hypertension was diagnosed in 7% (4) of pregnant women in the age range of 18-39 years, while antepartum chronic hypertension was observed in 3% of women (27). In 110 hypertensive patients treated with antihypertensive drugs, Gangwani et al measured RNFLT by OCT. They found that RNFLT decreased in patients with higher arterial pressure (28).

Conclusion

In general, our study showed that the increase in IOP occurs during both types of delivery NVD and CS; however, the type of delivery does not have a significant effect on the thickness of RNFL. Nonetheless, this increase in IOP may lead to different outcomes in women with pre-existing glaucoma or glaucoma risk factors. Therefore, in cases with a positive background of glaucoma, specialized examinations and delivery under the supervision of a specialist are recommended.

Limitations of the study

Due to the corona pandemic, some of the cases did not return to a medical center for their follow-up. There was also poor cooperation in NVD group for IOP measurement during delivery.

Authors' contribution

Conceptualization: AS, AK.
Methodology: AS.
Validation: PJ and AS.
Formal analysis: SN and AS.
Investigation: SN.
Resources: PJ, AK, SN.
Data curation: AS and SN.
Writing–original draft preparation: SN.
Writing–review and editing: SN, AS, AK, PJ.
Visualization: AS.
Supervision: AS, AK.
Project administration: AS, AK.

Conflicts of interest

The authors declare that they have no conflicts of interest.

Ethical issues

The research followed the tenets of the Declaration of Helsinki. The Ethics Committee of Ahvaz Jundishapur University of Medical Sciences approved this study (Ethical code # IR.AJUMS.REC.1398.516). Accordingly, written informed consent was taken from all participants before any intervention. This study was extracted from residency dissertation of ophthalmology by Sanaz Nazari at this university (Thesis #IORC-9808). Ethical issues (including plagiarism, data fabrication and double publication) have been completely observed by the authors.

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